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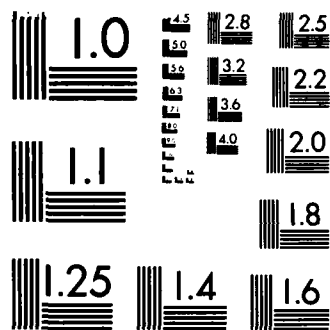
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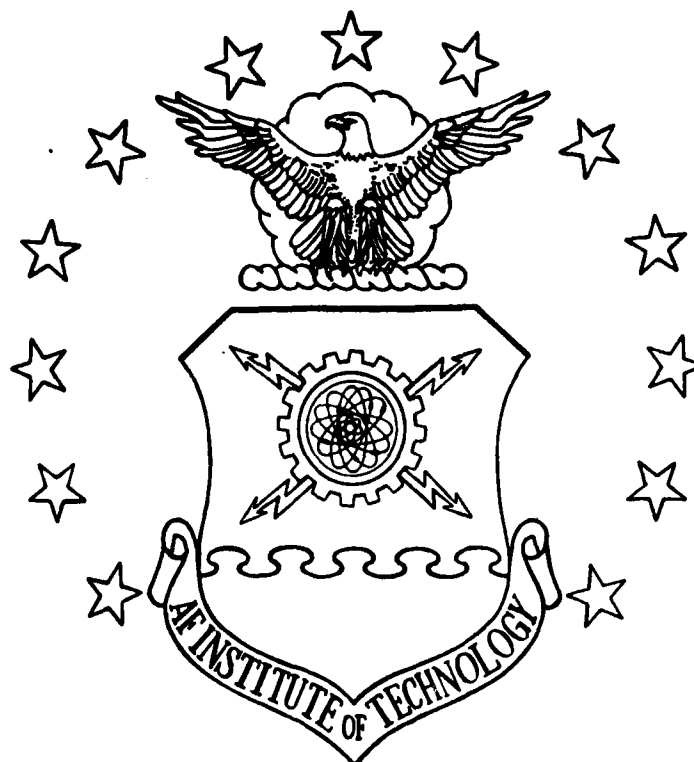
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AN INVESTIGATION OF THE DECISION VARIABLES
THAT AFFECT SPACE WEAPON SYSTEM PROCUREMENT

THESIS

Paul V. Borish
Captain, USAF

AFIT/GSM/LSY/856-4

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**AN INVESTIGATION OF THE DECISION VARIABLES THAT AFFECT
SPACE WEAPON SYSTEM PROCUREMENT**

THESIS

**Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Systems Management**

Paul V. Borish, B.S.

Captain, USAF

September 1985

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Preface

Within space weapon system acquisition, the full funding policy and the three year obligation availability of procurement funds have adversely affected program managers in this area. Program managers are sometimes forced to make less than optimal decisions in the cost, schedule, technical, and logistical concerns.

I became interested in this area based on my previous experience at Headquarters Space Division, Los Angeles, CA. The program office that I worked for was about to lose approximately ten million dollars of uncommitted procurement funds at the end of the third year of obligational availability. This did not make sense to myself and others since the contract was for the first two production satellites and only about 60% complete.

In performing this research and writing this thesis, I have had a great deal of help from others. I am deeply indebted to my faculty advisor, Dr. A. P. D'Angelo, for his gentle pushing of its completion. I also wish to thank my reader Major Presutti for his patience and calming effect. A special thanks goes to Dr. Steele of the Department of Behavioral Sciences for his computer and statistical expertise in SPSS and factor analysis. I also wish to thank all of the program managers and others at Headquarters Space Division, Los Angeles AFS, CA for their participation in the interviews and data gathering. Finally, I wish to express

my deepest appreciation to both my wife, Ellen, for her understanding and concern, and my son, Bryan, for helping me maintain a healthy state of mind.

Paul V. Borish

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Abstract

The full funding policy and the three year obligation availability of procurement funds were identified as the major constraints limiting program managers of space weapon systems in their acquisition activities. In order to evaluate the effect of these constraints on space weapon system acquisitions, twelve variables, identified through the literature review, were used to gain an understanding of the problem. Program managers believed that these variables created problems that could only be solved by changing the acquisition process.

Personal interviews were conducted and the importance of each variable in affecting the program manager's efficiency was identified. Two data analysis techniques were used: qualitative and factor analysis. Factor analysis was conducted using the rating of importance for each variable and this lead to four underlying factors. The factor identified as limiting program managers the most was labeled program uncertainties.

From the program manager's viewpoint, the study resulted in a finding that, although one constraint (three year obligational availability of procurement funds) was not optimal, it was acceptable. Program managers of space weapon systems have demonstrated this by adapting their methods to operate within this time limit. The full funding policy constraint, however, continues to be a problem, and should be reviewed.

AN INVESTIGATION OF THE DECISION VARIABLES THAT AFFECT SPACE WEAPON SYSTEM PROCUREMENT

I. Introduction

General Issue

Article 1, Section 8 of the United States Constitution states:

The Congress shall have power to ... provide for the common defense and general welfare of the United States, ... raise and support armies, but no appropriation of money to that use shall be for a longer term than two years

The Constitution also gives Congress power to make rules for the government and for the regulation of land and naval forces.

Based on these sections of the Constitution, Congress not only provides funds for the Department of Defense, but specifically dictates how this money shall be used. They do this by enacting legislation which, after Presidential approval, provides funds for various national needs. Sometimes Congress will identify a particular program that will be authorized and appropriated a certain level of funds. Congress identifies funds by the use of various appropriations and uses these appropriations to direct how our national resources will be spent. Each appropriation is constrained by: the purpose of the appropriation, who is using the funds, and the length of obligational availability. For example, Congress determines the amount of funds available for each armed service. Each service is also restricted to

Congressionally specified dollar limits for the various types of acquisitions. Research and development, production, and operations and maintenance efforts are a few examples. Each of these types of efforts are classified into separate appropriations that are further constrained via their time availability for new obligations. For example, the operations and maintenance appropriation is available for one year; the research and development appropriation is available for two years; and the procurement appropriations are available from three to five years. The Department of Defense must operate within these funding and time constraints. Exceptions to these rules will be discussed in Chapter Two, Literature Review.

Over the years, recommendations and changes have been made, but solutions to problems posed by the acquisition process seem to become more complicated and difficult to resolve with each passing year. The acquisition process currently used by Department of Defense program managers has existed for only a short time. However, program managers of space related weapon systems contend that conventional acquisition procedures are not conducive to accomplishing timely and efficient deployment of critical space hardware. These program managers state that the acquisition process is too restrictive for modern weapon system procurement. If this process is too restrictive, perhaps it should be adjusted to more closely meet the needs of today's space weapon system program managers.

Specific Problem

The restrictive combination of the full funding policy and the initial obligational availability on procurement appropriations appears to have adversely affected the performance of program managers of space systems. Full funding is a Congressional policy in which the total cost of an end item is funded at the time it is authorized to be initiated. Funds are obligated at this time; however, any contingency funds remain available for an additional specified period of time depending on the appropriation.

Congress currently separates appropriations into five broad classifications: Personnel, Operation and Maintenance, Procurement, Research and Development, and Construction (A:9). Figure 1, Air Force Appropriations, illustrates the different constraints of each appropriation. In the Air Force, the Procurement appropriation is further subdivided into the aircraft, missile, and other procurement appropriations with the missile procurement appropriation providing funds for most space related programs.

Background

In the past, Congress has been willing to adjust specific appropriations to better serve changing needs. For example, when aircraft were first procured, they were bought with the same appropriation as tanks (F:3). As airpower became more important, the United States Air Force was created, replacing the Army Air Corps, and a separate aircraft procurement appropriation was

established. Technology then moved our nation into the missile era and intercontinental ballistic missiles were procured using the aircraft procurement appropriation (F:3). Subsequently, as missile procurement became a larger part of the aircraft appropriation, a separate missile procurement appropriation was established. However, despite the fact that the United States government has now been active in space since the late 1950s, it continues to procure spacecraft and launch vehicles through the missile procurement appropriation.

| Appropriation | | Use | Length of Initial Availability |
|--|--------|---|--------------------------------------|
| Name | Number | | |
| Research, Development, Test and Evaluation (RDT&E) | 3600 | Provides for RDT&E and for operating and maintaining R&D facilities | 2 years |
| Procurement | | | |
| Aircraft | 3010 | Provides for fabricating and procuring aircraft weapon systems | 3 years |
| Missile | 3020 | Provides for fabricating and procuring missile weapon systems | 3 years |
| Other | 3080 | Provides for fabricating and procuring weapon systems not included in the aircraft or missile appropriation | 3 years |
| Operation and Maintenance | 3400 | Provides for expenses necessary for the operation, maintenance, and administration of the Air Force | 1 year |

Figure 1. Air Force Appropriations (Not Inclusive)

Scope of Research

Although a separate space appropriation has been considered in the past, none has been provided and probably will not be in the foreseeable future. The reasons for this are discussed in Chapter 2, Literature Review. The intent of this research is not to investigate the feasibility and advantages of such an approach. Rather, the research objective is limited to identifying the variables that are affecting the performance of program managers in this area and their relative importance in the procurement of space weapon systems.

This research will address, but not evaluate the composition of the procurement appropriation in general and previous changes to the acquisition process. Previous approaches to answering the general issue of this research are identified; however, any problems associated with actual implementation of these recommendations are not addressed.

Research Questions

This research attempts to address the hypothesis: Space weapon system procurement is not different than the procurement of non-space weapon systems. In order to test this hypothesis, two research questions need to be answered.

Research Question 1. What, if any, management decision variables exist in the weapon system acquisition process that are unique to the procurement of space systems?

Research Question 2. Of the variables identified, what is their relative importance as to their ability to affect the procurement of space weapon systems?

II. Literature Review

This chapter provides additional background information concerning: previous appropriation changes, reasons why program managers believe a change is necessary, and recent studies that recommended approaches to alleviate these problems.

When a problem exists in the acquisition process that requires a change to an existing appropriation or the establishment of a new appropriation, specific Congressional action is required. In the past, Congress has modified appropriations in order to better accommodate current needs.

The National Security Act of 1947 and its 1949 Amendments are excellent examples. This Act and its amendments provided a Secretary for the Department of Defense and each of the Armed Services with the Secretary for the Department of Defense acting as coordinator for the three services. At that time, the Secretary of Defense was given greater financial management authority (16:9). Although there was additional financial authority granted the Secretary for the Department of Defense, Congress maintained its oversight by requiring the submittal of performance budgets (16:9). The budget and accounting structures for each service were different prior to the passage of this Act with each administering its own separate appropriations. The performance budgets requested by Congress helped standardize these organizational appropriations into broad functional classifications such as Personnel, Operation and Maintenance, Procurement, Research and Development, and Construction (16:9).

This change enabled the military service appropriations to be compared to one another and separated the one year accounts from the longer term accounts (16:10).

Other examples of congressionally approved appropriation changes occurred as the technology base of the United States continued to grow and provide increasingly more effective military capabilities. Mechanized cavalry replaced foot soldiers and horses. Propeller driven aircraft are being replaced with jets. Intercontinental missiles, space satellites and space shuttles are now commonplace. As technology moves our horizons forward, Congress has updated the acquisition process either by changing or establishing appropriations as needed. As mentioned in Chapter One, when aircraft were first procured, they were bought using the same appropriation as tanks (2:3). As airpower became more important, the aircraft procurement appropriation was established. When missiles were developed, the aircraft appropriation was first used to procure them (2:3). However, as missile procurement increased, a separate missile procurement appropriation was established. Although, in the past, Congress has changed or established appropriations to meet the changing procurement needs, this has not occurred in the space arena. The United States government has now been active in space since the late 1950s, but has continued to procure spacecraft and launch vehicles with the missile procurement appropriation. Has the time come for an appropriation change in the space arena?

First of all, there can be no doubt that the Department of Defense's role in space is increasing. The military uses of

space are continuing to grow as new missions are created by changes in national goals and defense requirements. The Department of Defense operational spacecraft inventory is growing at a rapid pace and the military use of space is increasing in areas such as communications, navigation, surveillance, and meteorology (18:1). The acquisition process which is currently used to procure spacecraft has not changed since the first space launch (21:9). As a result, program managers are presently "attempting to develop and procure highly sophisticated, state-of-the-art spacecraft with an acquisition system designed for aircraft and missile systems" (18:1). The acquisition process used for procuring space systems is designed for "high production rates, modifications to incorporate newer technology, and spares" (21:9). Space weapon system procurement is at the same point in its evolution that missile systems were 25-30 years ago when a new procurement appropriation was established to handle the differences between missile and aircraft systems (17:4). As a result of the Department of Defense's increasing role in space, some authorities on space procurement feel that the time has come to modify our acquisition process for the procurement of space systems by providing a separate space procurement appropriation (2:3).

There are three individuals that stand out among others as experts in this area. They are: Colonel William F. H. Zersen, the Comptroller for Headquarters Space Division, Los Angeles, CA; Mr Frank G. Atwater, working for the Comptroller at Headquarters Space Division; and Mr Robert M. Ebersold, the Director of

Program Control for the Upper Stages Program Office. All three have written papers and given speeches on the subject of a new space appropriation.

These men, with the help of others, provided several reasons why program managers feel that a change in the acquisition process for space weapon system procurement is necessary. They include: the full funding policy, production rates, development versus production differences, the number of appropriations currently used, orbital performance incentives, high risk technology, and unrealistic budget estimates. Each of these reasons are further developed in the following paragraphs.

Full Funding Policy

Congress now requires full funding for programs in the procurement phase of the acquisition cycle. Department of Defense Directive 7200.4 directs that the full funding concept for procurement programs be implemented in all services (C). In practice, full funding means that each annual procurement appropriation request must indicate the funds necessary to cover all estimated costs of acquiring a given quantity of useable end items. In other words, "no procurement request should be dependent upon future year appropriations to make it whole" (1:4). Full funding is specifically defined within the Procurement Appropriations Act and it has no application to any other appropriations contained in other titles of the Act (1:1). Full funding has caused the services several problems.

First, the existence of significant unobligated balances in

the procurement accounts at the end of each fiscal year has drawn considerable criticism from Congress. An unobligated balance occurs when the total amount appropriated by Congress for an end item is not obligated in that fiscal year. In the case of procurement appropriations, this may occur at each of the three years of obligational availability. Funds that were not obligated are used as a management reserve account for engineering changes that may become necessary. A management reserve is necessary due to the full funding policy and is based on a percentage of the initial total cost of the end item. If no management reserve is available, additional funds must be appropriated and be of the same fiscal year as the original procurement year. Although this frequently occurs, Congressional interest in unobligated balances has increased over the years and detailed explanations are required (1:3). The services are concerned that Congress may limit their authorizations due to these large unobligated balances (1:3). A major cause of these unobligated balances is the budget for engineering changes (1:6). Unfortunately, engineering changes are requirements unknown prior to contract award. Obviously, the funds required for these changes cannot be obligated until the change is authorized and directed. Since engineering changes occur throughout the life of the production contract, unobligated balances occur.

A second reason that the full funding policy has caused problems is that procurement funds are currently available for obligation for only three years within the Air Force. For example, missile procurement funds authorized and appropriated

for fiscal year 1985 remain available for obligation from 1 October 1984 through 30 September 1987. After this time, they expire but remain available for liquidation of obligations and authorized obligation adjustments for an additional two years before lapsing and being placed in the US Treasury "M" Account. Figure 2, Obligation Availability, provides a more detailed comparison of the differences between current, expired, and lapsed appropriations.

| RDTE | FY | FY+1 | FY+2 | FY+3 | FY+4 | FY+5 |
|-------------|---|------|-------------------------------|------|--------------------------|------|
| | Controlled Accounts | | Expired Accounts | | Lapsed or "M" Accounts | |
| Controls: | Fiscal Year Appropriation Program Project | | Fiscal Year Appropriation | | Appropriation | |
| Purpose: | Program Execution of Directed/ Funded Items | | Closeout Contract Adjustments | | | |
| Accounting: | | | Full Set of Records | | Unliquidated Obligations | |
| Procurement | FY | FY+1 | FY+2 | FY+3 | FY+4 | FY+5 |

Figure 2. Obligation Availability

In addition to the full funding policy, production rates and high risk technology (discussed later) contribute to unobligated funds at the end of each fiscal year. This combination makes it "easy to see that some of these funds, ..., would be unobligated at the end of the first year, and even two or three years" (1:7).

This often creates the need to use expired and/or lapsed ("M" Account) funds for required changes. With the extensive justification and time required to obtain approval to use expired or lapsed funds, the potential for launch delays on space systems is increased. Within satellite procurements, "the use of full-funding makes it difficult to obtain fund increments necessary to keep probability of mission success at high levels if problems develop", especially in the areas of recycle, retest, and replacement (6:2).

The combination of the full funding policy and the three year obligational time availability is alleged to have caused problems in other areas as well. Although not supported by research, it has been asserted that the contract price will increase due to long term economic uncertainties and that the requirement to defend having a management reserve for these uncertainties over an extended period of time reduces the effectiveness and efficiency of the program manager. Another assertion is that this combination reduces the effectiveness of contract incentive provisions (19:1). The validity of these assertions is left for future researchers to investigate.

Production Rates

In the production of a space weapon system, spacecraft "are indeed unique systems" (21:9). There is very little resemblance to a conventional production line. Spacecraft are not manufactured on an assembly line but are often built one of a kind, one at a time (17:4); correspondingly, their delivery rates

are also very low. For example, the production time for a spacecraft is typically four to five years. In addition, the time between contract award and spacecraft launch is even longer (2:5).

One of the results of small production lots and lengthy production times is the incorporation of the latest technology as it becomes available, even up to launch. This is a major contributor to the engineering changes problem noted under the full funding policy discussion. Due to the lengthy production time, engineering changes may occur late enough to require expired and/or lapsed funds, thus increasing the severity of the situation.

Development Versus Production

There is little difference between a development and a production spacecraft. The largest cost of spacecraft is incurred during the development and production phases, as contrasted with conventional weapon systems, such as aircraft, which incur their largest cost during use in the field (17:5). This situation results from the limited ability to repair in space. Because of this, current technology and capabilities are incorporated up to launch (17:5).

This may be changing due to the in-space repair potential provided by the Space Transportation System (STS), commonly referred to as the Space Shuttle. However, a recent research effort on maintenance of space systems provided a different perspective. The research dealt with the idea of preventive

maintenance on space systems. It attempted to identify components within satellites that could be used as prospective candidates for preventive maintenance. However, the uniqueness of each satellite allowed for only one component (a traveling wave tube amplifier, TWT) to be considered. The research concluded that preventive maintenance is inappropriate for space systems at this time (12:5).

Since only one component was identified as common among satellites, it may indicate that the difference between development and production satellites will remain small and that all of the current technology and capabilities will continue to be incorporated up to launch.

Although the differences between the research and development and production satellites are small, the differences between the research and development satellite and the operational spacecraft are fewer (17:5). Due to the cost of launch, which includes the cost of the spacecraft and launch vehicle and an upper stage if necessary, test flights are "out of the question" (10:3). Unlike aircraft and other types of weapon systems, the first flight of a space system must be operational, even if it may be a research and development spacecraft (10:3). Therefore, the correction of orbital deficiencies must be incorporated into the next production vehicle. In this view, "development remains an ongoing process throughout the life of a program" (8:1). This usually forces program managers to acquire space systems in small quantity buys relative to conventional weapon systems that are bought in lots of a hundred or more.

Current Appropriations Use

The Department of Defense deals with many different appropriations with programs being funded according to their stage in the acquisition process: the research and development phase, the production phase, or the operational phase. In addition, some programs are joint service funded. This results in multi-funded contracts that require a multitude of program office checks, balances, and controls (21:10). Many of these contracts use expired and/or lapsed as well as current appropriations (20:1). The reason that expired and/or lapsed funds are necessary is that the currently used missile procurement funds are initially available for obligation for only three years. As discussed earlier, the combination of the three year procurement appropriation and the long production time for spacecraft has brought about the use of expired and/or lapsed funds when engineering changes become necessary (21:10). Both of these type funds may also be required in program "stretch-outs" and cost overruns that are paid at contract closeouts (6:3). This is a time consuming practice because of the justification required to obtain expired or lapsed funds. Since each appropriation is budgeted, justified, and accounted for separately, each appropriation must be tracked and reported separately. This leads to additional workloads on program control and the procurement offices. Program control must "maintain a separate set of books for each appropriation" and procurement must "separate the different appropriations on the same contract by the use of line items and clauses" (2:9).

The use of current and expired and/or lapsed appropriations on these contracts "tend to distort the full amounts expended on a system/program" (6:3). If Congress has set specific limits on a program, it expects the full funding policy to indicate the total system cost. When additional current appropriations are necessary, congressional approval is required; however, when expired or lapsed funds are required, Headquarters Air Force can approve the necessary funds, if they are available. Therefore, Congress would not be informed of the total acquisition costs.

Similar difficulties in tracking funds are experienced by civilian contractors used by the government. The use of multiple appropriations with different time availabilities on a single contract has required civilian contractors to implement complex accounting and cost reporting procedures (8:1). Contractors must bill the government by contract line item. In addition, they may be required to indicate which appropriation was used, thus requiring them to track costs by our appropriations. The increased cost of implementing these procedures are then passed on to the government in some form (21:10).

Performance Incentives

Performance incentives in the form of monetary payments are used to motivate the contractor "to turn out a product that meets significantly advanced performance goals" (7:339). The period of performance of satellite procurement contracts requires funds to be available for approximately eight to ten years after the contract award date (6:3). Many performance incentives on these

contracts will not be earned or paid until the contract nears completion. Under the current full funding concept, this requires payments from expired and/or lapsed accounts (6:3). It also requires that large amounts of contingency funds be set aside for such possible use. The Program Office for Upper Stages, specifically for the Initial Upper Stage (IUS) provides an excellent example. When the contract was awarded, four million dollars was set aside for performance incentives that eventually expired and lapsed (4:8).

High Risk Technology

The high risk technology of Department of Defense weapon systems has been recognized by Congress. The House Appropriations Committee's report on the 1978 Department of Defense Appropriation Bill points out that many weapon system programs are not prepared to enter the procurement phase as fully funded programs and specifically notes that:

There has been a tendency too often to curtail and shorten research and development effort when faced with a limitation of funding usually caused by program cost increases. The effect of such calculated decisions is inadequate and unrealistic testing, the introduction of deficient weapons and other equipment into our inventories, and the subsequent use of the procurement budget to correct the inadequacies of the development program. (6:2)

The technology used in satellite production is highly advanced. As previously stated, one of the reasons for this is the lack of maintenance and repair capability in space, which dictates that all latest technology be incorporated prior to launch. This makes satellite procurements different from other

Department of Defense types of procurement in that the production phase of satellites is essentially an extension of the research and development phase (6:2). The production phase is only at a slightly lower risk; therefore, "satellites are also most susceptible" to the problems identified by the House Report above (6:2). Due to the high risk technology and the full funding requirement of the procurement phase, the program manager "is at a substantial disadvantage" when forecasting the resources required (6:2). For this reason, the end product "tends to be tailored to the amount of funds available because of the difficulty in obtaining additional funds if required to assure mission success" (6:2). The limitation of funds and the justification required to obtain additional funds for engineering changes add to the probability of this occurring. The program manager's inability to forecast requirements is further discussed in the next section.

Unrealistic Budget Estimates

The high risk technology of space weapon systems makes it probable that design changes will occur during the production phase. The nature, magnitude, and costs associated with these changes are difficult to predict (6:4). The budget estimates on space weapon systems "are particularly susceptible to technological breakthroughs or improvements", since they are incorporated any time prior to launch (6:3).

There are no spare parts or back-up systems provided for under full funded budget estimates. This presents a unique

problem for space related program managers. For example, a malfunction of a part or total system failure could occur. In space systems, "any malfunction of parts forces the program manager to use parts intended for follow-on systems" (6:4). When the loss of the total system occurs, the program manager must accelerate the production schedule to achieve delivery of the next approved system, if necessary to meet mission requirements (6:4). Whether the program manager uses parts intended for future production units or accelerates the production schedule, additional funds are usually required which were not planned or budgeted for.

There are other factors that contribute to unrealistic budget estimates that are not unique to space weapon system procurement. Program managers of production programs are required to budget well in advance of actual need. The great difficulty of predicting the rate of inflation, changes in requirements, technological changes, and the rising costs of labor and materials, contribute to unrealistic budget estimates. These same factors have caused contractors to refuse quoting firm prices in long term procurements (6:4).

Problem Summary

A number of reasons why program managers believe that a change in the acquisition process for space weapon system procurement is necessary have been identified. They were: the full funding policy, production rates, the lack of development versus production differences, the number of appropriations

currently being used, performance incentives, high risk technology, and unrealistic budget estimates. Solutions to these problems have also been proposed. The following proposals are included among these.

Previous Approaches

Several papers have been written concerning the need for a new space appropriation to address the problems encountered in the current acquisition process for space systems. The concept of a Congressional appropriation specifically set aside for space and space related systems is not new. It has been discussed at various levels of government, including the Assistant Secretary of the Air Force for Financial Management (22:1). There have been several studies conducted regarding the composition of a new space appropriation.

All of the past studies have had the common thread of incremental funding which can be defined as the "citation of funds on a contract in an amount necessary to continue effort for one fiscal year" (7:340). In the past, incremental funding has been restricted to the RDT&E appropriation. This is in contrast to procurement appropriations, which are currently fully funded, and the operation and maintenance appropriation, which is annually funded. Several different versions of incremental funding are summarized below.

Study 1. In 1977, a SAMSO (Space and Missile System Organization, now called Headquarters Space Division) study of the funding policy for satellite procurement appropriations was

conducted. In order to alleviate the problems previously identified in the current acquisition process, it recommended that the existing missile procurement appropriation be changed from fully funded to incrementally funded (6:6). The study also helped to identify the important factors that were causing the need for a change. Most of these factors were previously discussed and summarized. The factors not previously identified were: the lack of inventory and funds for quick reaction in case of failure and that incremental funding "would essentially eliminate the need to have large sums of funds obligated in advance of contract needs" (6:5). These factors were identified; however, no further discussion was provided.

Although this study did not describe how this would help eliminate the problems in the current acquisition process, it did identify several reasons against the use of incremental funding in satellite procurement. First, the number of contract modifications would increase in order to periodically obligate additional funds. Second, an incrementally funded appropriation would have to undergo Congressional budget scrutiny each year. This could result in funding reductions and program re-directions. Finally, it may be viewed as a reduction in Congress' and the public's ability to see the total cost of a weapon system (6:5).

Study 2. Colonel Zersen, identified earlier as an expert in this area, suggested that the new appropriation should combine four of the seven appropriations currently used by space systems. The types of appropriations that are currently used by space

systems are: Research and Development (3600); Missile Procurement (3020); Other Procurement (3080); Incremental Missile Procurement of SAF/SS, special projects (3020); Incremental Other Procurement of SAF/SS (3080); Operations and Maintenance (3400); and Military Construction (3300) (22:2). This study's recommendation included all of these except for the Research and Development (3600), non-space Military Construction (3300), and non-space launch related efforts of Operations and Maintenance (3400) and incorporated the remaining appropriations into the new space appropriation under a new number in order to avoid confusion (22:13). In addition, the new appropriation would be incrementally funded and available for obligation for three years (22:14).

Colonel Zersen suggested that a new appropriation designed in this way would eliminate the reasons why program managers believe that a change in the current acquisition process is necessary. These reasons were discussed prior to this section on previous approaches. He also suggested that such an appropriation would provide other advantages. First, it would "enhance the visibility Congress has over the dollars they give us" by providing a single appropriation manager. Second, it would "reduce the possibility of diffusing space decisions" and finally it would group similar functions together under the same appropriation (22:13).

This study also discussed two reasons for not using a new space appropriation. These were flexibility and oversight (22:10). Although a new space appropriation would provide

program managers with additional flexibility in budgeting and contracting, it would "reduce the flexibility of DOD to be able to utilize or move funded dollars from one area to another"

(22:11). In the area of oversight, Colonel Zersen stated:

There currently are many different Congressional committees that have oversight of the dollars allocated for space systems. Each one has its own area of expertise. By changing to a space appropriation you would expect that the numbers of these different committees could be reduced--simplify the process. However, this could obviously be viewed as a reduction in the oversight that Congress currently has over the space system. (22:11)

Colonel Zersen has been a prominent authority in this area for several years and in a briefing to the Air Force Accounting and Finance Center in Denver, he added that a new space appropriation composed in this manner would "streamline our program management, provide more flexibility within the budget area, facilitate multiyear contracting, and it should reduce contracting costs and promote efficiency" (21:12). In addition, he believed that:

... a single space appropriation will reduce the financial reporting workload, reduce contractual complexities, reduce the number of higher headquarters required reports, and finally, and maybe most important, may enable budget estimates to be more accurate. ..., more accurate budget estimates reduces the amount of time management requires to generate and validate required dollars. (21:13)

This study also identified some obstacles that would have to be overcome if this approach were to be taken. First, the establishment of a new space appropriation would require Congressional support and approval and second, the new appropriation would limit the Air Force's flexibility in

reprogramming actions by reducing the missile procurement base (21:13).

Study 3. Another prominent authority in this area is Mr Frank G. Atwater. His study resulted in the same conclusions and recommended the same new appropriation characteristics as Study 2; however, it further identified areas where an incrementally funded space appropriation would help. By combining the various appropriations currently used to procure space systems, the study indicated that a new space appropriation would improve the efficiency of the program manager, the procurement office, the paying station, and the contractor. Specifics mentioned in the study include the following:

The program manager's efficiency would be improved by eliminating the multiple approval chains required by the different appropriations. The new appropriation would reduce the planning, programming, execution, and tracking requirements by reducing the number of budget submissions and simplifying financial analysis and obligation/expenditure forecasting (2:13).

When implementing the new space appropriation, the procurement office's efficiency would be improved by reducing the "contractual complexity and contract performance reporting documentation", decreasing the size and number of contracts, and simplifying the contract proposal (2:13).

The paying station's efficiency would be improved by having to input less data into the payment system, having to report less data between the disbursing and funding stations, and by reducing the chance of errors common when citing several different fund

citations (2:17).

The contractor's efficiency would improve similarly with the government procurement offices'. The net benefit would be a reduction in overhead costs through the reduction of paperwork (2:17).

Study 4. This study agreed with a new space appropriation and its composition; however, in addition to being incrementally funded, the funds would be available for obligation for up to five years. The additional advantages stated in this study are:

This would allow more economical buy quantities while at the same time compensating for the complexities of the technology and the length of the production cycles. Also, a three (or five) year appropriation will allow for a constantly changing launch schedule ... (17:8)

Study 5. A more recent Air Staff study developed several alternatives for a space appropriation and provided a recommendation to SAF/FM. The characteristics and requirements of this appropriation would be quite different from those previously discussed. The new space appropriation would include the space related "RDT&E procurement of satellites, other space vehicles, boosters, peculiar launch equipment, spares, launch activity, ground terminals, cryptographic equipment, and Space Launch Services portion of O&M" (8:1). The appropriation would again be incrementally funded, but be available for obligation for two years with the exception of certain operational charges that would be funded annually (8:2).

The study identified four alternatives. They were:

Option 1 - Combine all space related RDT&E (including Engineering Development 6.4), Procurement and O&M into the new appropriation.

Option 2 - Same as 1 except include only Space Launch Services (SLS) portion of O&M.

Option 3 - Combine all space related Procurement and O&M.

Option 4 - Same as 3 except include only SLS portion of O&M. (B:2)

These options were designed to alleviate the problems identified earlier. The study also identified other options provided by various Air Staff offices that would solve some of the problems to a varying degree. First, the Space Launch Services (SLS) portion of the Operations and Maintenance appropriation could be moved to the missile (3020) procurement appropriation. Another was to pursue incremental funding for major space program procurements only. And finally, the space acquisition process could be changed to be more streamlined by reducing program reviews, combining DSARC milestones, and delegating D&F authority (B:4).

There are significant advantages of implementing a new space appropriation using the options suggested in this study. A new space appropriation would allow flexibility in the funding of space launches by removing the large yearly variations in the O&M appropriation. These yearly variations are primarily caused by launch delays or launch-on-demand programs. All the options would reduce the accounting complexity of funding integrity brought about by the close relationship between "Research & Development" and "Production" costs. At the same time, these options would reduce the number of different appropriations for a single contract. It was also suggested that it would provide

Congress a consolidated program scope of the space activities and contribute to space program accomplishment by allowing better coordination of planning and more efficient management of programs. The study further stated that it would help streamline management by providing a single appropriation manager vice three for each program. The advantages were not limited to the Department of Defense. A final major advantage would be that it would simplify contractor accounting and cost reporting (8:2-3).

The study also identified several disadvantages. First, the contemplated incremental funding commitments would probably reduce the programming flexibility during the Planning, Programming, and Budgeting System (PPBS) cycle. Second, incremental funding would reduce Congressional options to terminate procurements since full funding would be eliminated. Next, an additional appropriation would add to budget and accounting paperwork that would be required in order to administer it. Additionally, the establishment of a new appropriation could encourage other major program components which might claim uniqueness similar to space systems to ask for similar treatment. Finally, it would reduce the below threshold reprogramming flexibility (reprogramming within appropriations) and in turn increase the use of Secretary of Defense transfer authority contained in the general provisions of annual appropriations acts (reprogramming between appropriations) (8:3). This Air Staff study also identified the complexities of implementing any of the four basic options. First, a new appropriation would present a selling challenge to reviewers and

Congress, especially in light of recent Department of Defense initiatives to reduce government paperwork. Secondly, it would require Congressional Subcommittee agreement. These committees currently have responsibility for Research, Development, Test, and Evaluation (RDT&E), Procurement, and Operations and Maintenance, appropriations separately. Next, the approval cycle would include Department of Defense and the Office of Management and Budget approval along with Congressional approval and enactment into law. Finally, any action would require a recategorization of DOD space and space related programs (8:3-4).

The recommendation selected by the study was option 1, stating that it would solve the most significant problems previously identified. Option 2 was not selected due to its failure to solve the "disconnect between different appropriation periods of availability and single contracts" (8:4). Option 3 was not selected because it failed to distinguish the grey area between development and production units. Option 4 was rejected since it solved neither of the problems of options 2 and 3 (8:4).

Summary

Due to the increasing role of the military uses of space, space weapon system program managers believe that a change in the current acquisition process is necessary. Specifically, problems exist in the production phase with the appropriations currently being used. The problems encountered by space system program managers are: the full funding policy, current production rates, the lack of development versus production differences, the number

of appropriations currently being used, orbital performance incentives, high risk technology, and unrealistic budget estimates.

Solutions to these problems were presented in several studies that made recommendations to change the current acquisition process. These changes have been centered on establishing a new space appropriation and obtaining incremental funding authority. None of these previous recommendations have been accepted and probably will not be in the foreseeable future (D).

The extension of a procurement appropriation to longer than three years has been done. The Navy has a procurement appropriation, called "Shipbuilding and Conversion, Navy" that is available for obligation up to five years (11:136). This appropriation is subject to the same Congressional legislation as are the Air Force's procurement appropriations. This leads to the current recommendation at hand of extending the current missile procurement appropriation to have a longer than three year obligational availability, in order to possibly alleviate the problems unique to space system program managers.

III. Methodology

This chapter discusses the methodology followed for the collection of data and the analysis used to answer the research questions. These research questions, are stated in Chapter One, Introduction, need to be answered in order to identify the variables in the procurement process that may determine if there is a significant difference between space and non-space weapon system procurement that would impede the efficient acquisition of space weapon systems.

This chapter is divided into five parts: justification of approach, interview questions, analysis of data, scope, and limitations.

Justification of Approach

The researcher realized from previous experience that a problem for program managers could exist in the production phase of space weapon systems. Specifically, the three year obligational time availability of the procurement appropriations may not be conducive to the timely and efficient acquisition of space systems. A literature review was first conducted to verify that a problem did exist in the acquisition of space weapon systems. Through the literature review, the researcher noted that a problem did exist in the production phase of space weapon system procurement and that several suggestions to solve the problem were examined; however, to date, none of these suggestions have been incorporated into the existing procedures. The review also identified some operational variables that were

believed to be inhibiting the efficient acquisition of space systems in the production phase. These suggestions and operational problems were more fully developed in Chapter 2, Literature Review.

Four approaches were considered for data collection. The first two considered the use of a questionnaire. There are basically two types of questionnaires, closed question and open question. Both of these and a combination of the two were considered. The closed question would require respondents to choose one of several alternatives, rating them using a Likert scale. For example, the Likert scale may have a range from strongly agree to strongly disagree. Since the literature review, as expected, did not identify all the factors affecting the current acquisition process, this approach was rejected. Additionally, the closed question questionnaire was rejected since appropriate questions could not be developed due to the difficulty associated with defining each factor. The open question method would require the respondents to write-in their own responses. This type of questionnaire was rejected because of the time constraints faced by most program managers and the probability that not all the information necessary to test the research hypothesis would be received. The third method, a combination of both closed and open questions, was rejected for the same reasons just mentioned. Another reason for rejecting these methods was due to their inherent lack of flexibility. In each of these methods, the respondents would answer the question only, without the researcher having the opportunity to further

question areas of possible interest. Therefore, the approach chosen as the most acceptable method of data collection was the structured interview.

This approach was selected for several reasons. It eliminated the problems identified with the other three approaches and the structured questions assured that each question was asked in the same way. This compensated for the researcher's lack of experience as an interviewer.

Interview Questions

In order to insure currency concerning the factors impeding the efficient acquisition of space weapon systems, personal interviews were conducted. As previously stated, a structured approach was used. Before the interviews, a list of questions was prepared based on the information gained from the literature review and the experience of the researcher. The questions were prepared for the purpose of verifying that this information was still current and inclusive. They were designed to identify the factors that were inhibiting the efficient acquisition of space weapon systems. The structured approach allowed the individuals contacted to freely express their opinions and at the same time, provided the researcher with data necessary for statistical analysis. The questions used in the interviews can be found in Appendix A.

These questions provided an insight into each program and the problems they were experiencing. The program managers were also asked to rate each factor in importance, using a Likert

scale, and to give an overall ranking. For the individual factors, the question was:

Considering the three year procurement appropriation limitations, how does this factor rate in limiting your ability to effectively manage your program for cost, schedule, performance, or logistic requirements?

- 1 - Extremely Important
- 2 - Very Important
- 3 - Important
- 4 - Neutral
- 5 - Unimportant
- 6 - Very Unimportant
- 7 - Extremely Unimportant

For the overall ranking, the question was:

Again, considering the three year procurement appropriation limitations, prioritize each factor by how it limits your ability to effectively manage your program for cost, schedule, performance, or logistic requirements.

The answers to these questions were used to test the research hypothesis. A qualitative analysis and factor analysis were used and will be discussed next.

Analysis of Data

Two data analysis techniques were used to fully answer the research questions. The first method of data analysis used was a qualitative data analysis. It was felt that without this form of data analysis, some information may have been lost. Next, in order to determine the underlying factors, factor analysis was used. The question concerning each factor's importance was used as the statistical data base. All of the statistical analysis

presented here was run on the Harris 800 computer system using the Statistical Package for the Social Sciences (SPSS). Each of these techniques are further developed in the following paragraphs.

Qualitative Analysis. In the process of a structured interview, additional data may be presented that may be of some importance. A qualitative analysis was conducted for each individual variable in order to determine if a high percentage of program managers felt strongly on any particular reason for the variables importance or any other comments that may impact this research.

Factor Analysis. Factor analysis is a general scientific method for analyzing data with no restriction on the content of the data (15:13). In general terms, to factor analyze a variable is "to find a way in which the analyzed variable can be expressed as a linear combination of other variables" (14:211). Factor analysis has many applications which include: patterns of interrelationship, data reduction, structure, classification, scaling, hypothesis testing, data transformation, exploratory uses, and mapping (15:29-32). The technique used for this research was data reduction.

Factor analysis helps the researcher describe the variation in a mass of data. The data reduction technique factors this data into its basic dimensions. These dimensions "are a concise embodiment of the data variation in the original matrix and thus can be used in place" of the original variables (15:29). In order to be able to reduce the mass amount of data, there must be

some variation in the data.

Although it is possible to factor analyze any matrix, not all matrices will yield useful factors (15:13). There must be meaningful variability in the data for factor analysis to have any value. For example, if the data has no variation, then only one factor will be derived. If the data has only random variation, then factor analysis will "delineate only patterns of chance covariation" (15:13).

Factor analysis is becoming more widely accepted, especially as a data reduction technique; however, it is not without criticism. Two of these criticisms need to be identified for this research. They are level of measurement and that factor analysis is arbitrary (15:17-18).

There are four traditional level of measurement classifications: nominal, ordinal, interval, and ratio. Each of these are distinguished by their ordering and distance properties. In this statistical analysis, the researcher noted that the data to be used was, in its strictest form, an ordinal-level measurement. In ordinal-level measurement, it is possible to rank order the different categories; however, the distance between these categories is not known, even when numeric values are used for category names. In the use of Likert scales, the ordering is known, but the distance between each category may not be in terms of fixed and equal units. The statistical analysis used here requires a minimum level of measurement of interval. The interval-level of measurement is the next highest level of measurement that includes the properties of ordinal-level

measurement and has the additional properties of fixed and equal units between categories. An assumption is made that statistics originally designed for interval-level variables may be used with ordinal-level measurement. This is supported by several social scientists who argue that this is valid (13:276).

The second criticism was that factor analysis is arbitrary, meaning that different researchers can obtain different results using the same data and technique. However, since the factor model used in this research (component factor analysis) is mathematically unique, it is not possible to arrive at different results for the principal component matrix (presented in Appendix B). The arbitrariness stems "from the problems associated with rotating factors once a factor analysis has been completed" (15:18). Rotating adjusts the factor results "to a best fit with the separate patterns of interrelationships" (15:18). The adjustment technique chosen involves a subjective determination by the researcher; however, "mathematical solutions of the rotation problem and the availability of high-speed computers have largely done away with this possible source of arbitrariness" (15:18).

In order to accomplish the data reduction technique of factor analysis, a subprogram entitled "factor" of SPSS was used. This subprogram provides for several different methods of factoring. Principal factoring without iteration was used (PA1 in SPSS subprogram factor). This was chosen with the recommendation of faculty experts in statistical analysis of Likert scales and because the SPSS handbook states that it is the

most widely accepted method.

Factor analysis must be taken one step further by rotating the factors identified. This is desirable since the unrotated factors "may or may not give us a meaningful patterning of variables" (13:482). The method chosen for rotating the factors is called varimax. The reasons for this choice are the same as for the method of factoring.

After rotating the factors, they can be identified by determining which variables contributed to each of the factors using a factor loading of .40 or higher. In order to complete the factor analysis, the research needed to indicate whether or not there were significant differences between each of the identified factors.

A t-test was conducted to determine if significant differences existed between each clustering or group provided by the factor analysis. The results of the factor analysis enabled the researcher to identify the original variables related to each of the new factors. By using these variables, a mean was established for each underlying factor. The t-test was conducted and since this research was concerned only whether or not a significant difference exists, a two-tailed test was used with a significance level of .05.

Scope

Although the focus of this research was on all space systems, only Headquarters Space Division, Los Angeles Air Force Station, Los Angeles, CA was selected as the source of data. The

researcher realizes that space system acquisition occurs in other geographical areas; however, Headquarters Space Division constitutes a significantly large portion of the total number of space related program managers that any results obtained there can be generalized to all space systems. This is true because Headquarters Space Division contained twenty of the thirty eight program element codes listed as space-related programs (8). The researcher attempted to interview as many different programs as possible with a goal of twenty personal interviews.

After data collection was complete, nineteen personal interviews were conducted with space-related program managers. This covered fourteen of the twenty Headquarters Space Division space-related program element codes. The interviews also covered eight different weapon systems.

Although no specific guidelines were used for selection, the following is how program experts were selected. Prospective program offices were contacted by telephone and were asked to participate in this thesis research; however, no classified programs were contacted in order to ensure that this research remain unclassified. The researcher requested either the Program Director, Deputy Program Director, Chief of Space Segment, or Chief of Cost Segment be interviewed from their program. The researcher attempted to interview at least one knowledgeable person from the space segment and the cost segment of each program interviewed. By doing so, it was felt that this would enable each program to answer all the interview questions with "up-to-date" knowledge.

Limitations

This method of selecting programs leads to the first limitation of this research. By using this method, no true randomization of respondents was established. However, since interviews were conducted over a large portion of the population using an unbiased method, the statistical analysis should remain valid.

Another limitation concerns the method used to gather the research data. As discussed earlier, the use of a questionnaire was rejected because of its inherent lack of flexibility in collecting non-statistical data. Therefore, the interview method was selected because of its distinct advantage of being flexible. However, one distinct disadvantage of interviews lies in the diversity of response. Thus, some of the responses cannot be grouped into clear-cut categories from which general observations can be derived; however, by using a qualitative analysis, this concern should be minimized.

IV. Discussion and Findings

The purpose of this chapter is to present the findings of this study using the methodology described in Chapter III. This chapter is divided into the following parts: respondent analysis, qualitative analysis, and factor analysis.

Respondent Analysis

In order to ensure that the information provided by the respondents could be assumed accurate and correct based on their broad experience, the first few questions of each interview were used to determine the knowledge base of each respondent. The nineteen subjects interviewed were involved with all four areas of the space related acquisition process; namely, the ground system, the space system, the upper stage, and the booster. Since some of the initial questions also dealt with the funding aspects of space system acquisition, program control personnel were also included in the sample (six of the nineteen interviewed). Although experience in any acquisition area helps program managers do their job more effectively, it was important to determine the experience level of each subject as a program manager in general and in space related acquisitions in particular. The nineteen subjects collectively had 276 years of experience as program managers and 211 years of experience as space related program managers, an average of 14.5 and 11.1 years, respectively. With this level of area coverage and experience, the responses represent the knowledgeable opinions of some the Air Force's most experienced program managers.

Qualitative Analysis

Although the statistical analysis of the original variables is most important in identifying the underlying factors, some information gathered through the interview process would be lost without qualitative analysis of the data. The qualitative analysis will discuss comments on the original variable categories used to collect data. These variables are defined in Appendix C.

Table I

Variable Ranking

| <u>Variable</u> | <u>Mean Rank</u> |
|--|------------------|
| Most limiting -- Complexity | 3.31 |
| Reliability | 3.58 |
| Length | 3.74 |
| Design changes | 4.26 |
| Inability to predict launch date | 5.28 |
| Concurrency | 5.42 |
| Launch delays | 6.17 |
| Product improvements | 6.47 |
| Other system reliance | 8.84 |
| Storage | 9.72 |
| Maintainability | 9.84 |
| Least limiting -- Performance incentives | 10.39 |

Prior to discussing the individual variable analysis, it is appropriate to provide the rank orders developed from the final question in each interview. Again, the question was: Considering the three year procurement appropriation limitations, prioritize each factor by how it limits your ability to effectively manage your program for cost, schedule, performance, and logistic requirements. The mean rank for each variable was calculated and used to provide an overall ranking of the

variables. This ranking is presented in Table I, Variable Ranking. Following the table, each variable is discussed in the same rank order.

Complexity. As discussed in Chapter 2, Literature Review, space related program managers procure their products in small quantities. Of all the piece parts used, most space systems use less than twenty percent of off-the-shelf items. The only respondent that identified using a higher percentage of off-the-shelf items was the program manager for ground systems which uses approximately ninety percent. Since these space related acquisitions are such small quantities, each unit is different and incorporates the latest technology. One reason for the high degree of complexity, mentioned several times during the interviews, was the requirement for highly redundant systems. The next major concern was that of the highly complex software requirements. The software is continuously tested and updated, which may cause additional changes to be made. Program managers believe that if their systems were not as complex and redundant, they would not be able to perform their missions and still maintain a high degree of success. This leads to the next most limiting factor, reliability.

Reliability. Space system program managers measure reliability using several different methods. The goal of each program manager is to achieve 100% system reliability. These methods include: measurement from the piece part on up, mean time between failure (usually for the black boxes), design life, mean mission duration, and system availability. The most

commonly used was that of system availability with all of the program managers interviewed achieving nearly 100%. The user demands this level of reliability for each different mission. This is achieved by increased use of redundant systems and use of software that can correct some problems with predetermined work arounds.

Length. The complexity and reliability requirements of space weapon systems have contributed to the increase in the length of system build times. The average build time was 39.5 months per unit. This does not include a one year long lead procurement. The average build time takes longer than the 36 months procurement appropriation time limit for new obligations. The shortest time reported was 24 months and the longest, 60 months. All the program managers indicated that the stated build times were for the ideal case, which seldom occurred.

The above build times were for one unit. Another problem arises when the quantity bought in a particular year is greater than one. With the limited special equipment and facilities required, the second and subsequent units are delayed by some amount depending on the resources of the contractor. This could extend the build time of these units to well beyond the three year obligational time availability of the missile procurement appropriation.

Design Changes. Although space acquisitions have a long build time, the number of design changes has been small. Even the design changes that have occurred have typically been a result of a previous launch failure. If a launch failure did not

occur, program managers stated that only changes that would improve reliability or reduce a mission deficiency are made.

User needs, concurrency, and the increased use of the space shuttle were the primary causes of design changes; however, since space systems are usually procured in small quantities, these changes were incorporated on subsequent buys. Of the changes that required an immediate change, only four were reported to have been after the initial procurement appropriation availability. Three of these requests were funded with either expired or lapsed funds, while one of these requests was redirected to use current funds within the program office.

Launch Prediction. When trying to maintain a schedule, most programs attempted to predict their launch within three months. Any changes to this was due to the priority of the program. Higher priority programs are able to "bump" other programs off their launch schedule. A program manager of one low priority program stated that he would be happy if he could predict the launch date within a one year window.

Although launch date prediction is an area of high uncertainty, each of the program managers first determined their build and launch schedule with the help of a standardized program. In order to improve launch date predictions, the Aerospace Corporation has developed a failure prediction process for all the satellite programs. This program, called the General Availability Process (GAP), attempts to incorporate any increases in mean mission duration since the older satellites are lasting much longer than their design lives. With the system performing

well and no user complaints, there would be no reason to launch, thus reducing the requirement of launching a new satellite.

Concurrency. All of the program managers interviewed managed or plan to manage under concurrency. The program managers felt that they must accept the risks because "we couldn't afford the gaps". Applying concurrency resulted in more design changes especially in software; however, all the program managers felt it was necessary to meet program requirements. Any design changes that did occur were not allowed to delay the overall schedule.

Launch Delays. The average number of delays per unit was 2.5 with the reasons varying greatly. Most delays were caused by a higher priority program "bumping" another program off the launching pad or a change in requirements. The length of delay ranged from a few days to two years depending on the circumstances of the program. This can be lengthened by the need for retest after a certain time period. This time period is subjectively determined and usually computed by the individual program offices based on their requirements. The three year procurement appropriation obligational availability is usually not a problem for launch delays since they are considered out-of-scope and new funding would be required. Any design changes occurring during these delays would also be considered out-of-scope.

Product Improvements. Unless the risk was acceptable, no changes were made during assembly on the production floor. All of the program managers believed that pre-planned product

improvements is the preferred approach. Even these were incorporated only when there would be no schedule delay; however, the changes usually occurred on the next quantity buy where there would be no funding impacts.

Other System Reliance. Program managers of space related systems are highly dependent on other systems. These program managers furnish black boxes that were developed by another program office, as Government Furnished Equipment (GFE), to the contractor, but state that this has not really been a problem. The real concern for satellite program managers is whether or not they will receive a booster and/or upper stage on time. Satellite program managers are 100% reliant on these other programs. The other program managers do not have this type of problem.

Storage. In discussing how storage planning and budgeting occurred, the responses were at both extremes. Some programs, usually the launch on demand programs, had contract provisions for storage up to a year. Most of the programs had contract options, but funding was not a problem because any requirement to store is considered an out-of-scope change to the contract and current dollars would be required.

Maintainability. Space weapon system program managers put little emphasis on this low priority area. The program managers interviewed presented no methods of measuring maintainability. Comments were restricted to making the system serviceable while on the ground, but nothing after launch. Program managers believe that with the high level of reliability (near 100% system

availability), there is no need for maintainence. When asked how the space shuttle has affected their maintainability requirements, the standard response was that they would be looking into this area in the next generation systems.

Performance Incentives. When performance incentives were first used at Headquarters Space Division, only positive incentives were used. Program managers stated that they are now moving to negative incentives primarily because they realize the magnitude of dollars that remain committed on the records and unused for perhaps five years or longer. This also helped to reduce their unobligated and unexpended funds that Congress is now using to identify possible future cuts in funding. This was previously discussed in Chapter II, Literature Review, Full Funding Policy.

Whether positive or negative incentives are used, no funding problems arise, since this is one area that a contingent liability can be used. Contingent liabilities allow funding to be set aside without fear of it being withdrawn after the initial three year obligational availability.

Other. Toward the end of each interview, the program managers were given the opportunity to voice any other concerns in this area. One point that was brought out was the fact that the government obligates too much money under the full funding policy that will not be spent until the system is completed. The programs abide by the full funding policy and then take the risk of future budget cuts for their lack of expenditures.

Factor Analysis

The application used in this factor analysis was data reduction. For a further understanding of factor analysis, the reader should review Chapter III, Methodology. It should be noted here that not all of the analysis is presented here; intermediate matrices are included in Appendix B, Statistical Program for Factor Analysis.

Table II

Matrix of Correlation Coefficients

| | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 | V10 | V11 | V12 |
|-----|-----|-----|-----|-----|------|------|-----|-----|------|------|------|------|
| V1 | 1.0 | .74 | .28 | .13 | .38 | .38 | .53 | .65 | .21 | .29 | .08 | .15 |
| V2 | | 1.0 | .46 | .02 | .32 | .32 | .18 | .77 | .30 | .55 | .04 | .30 |
| V3 | | | 1.0 | .08 | .45 | -.08 | .03 | .20 | -.05 | .65 | .15 | -.29 |
| V4 | | | | 1.0 | -.12 | .17 | .39 | .13 | -.22 | -.12 | .30 | -.02 |
| V5 | | | | | 1.0 | .47 | .07 | .35 | .11 | .59 | .14 | -.19 |
| V6 | | | | | | 1.0 | .07 | .45 | .54 | .37 | -.24 | .17 |
| V7 | | | | | | | 1.0 | .30 | -.14 | -.02 | .30 | .24 |
| V8 | | | | | | | | 1.0 | -.08 | .44 | .46 | .13 |
| V9 | | | | | | | | | 1.0 | .20 | -.90 | .55 |
| V10 | | | | | | | | | | 1.0 | .06 | -.05 |
| V11 | | | | | | | | | | | 1.0 | -.44 |
| V12 | | | | | | | | | | | | 1.0 |

V1 - Length
V2 - Launch Prediction
V3 - Launch Delays
V4 - Complexity
V5 - Reliability
V6 - Maintainability

V7 - Concurrency
V8 - Design Changes
V9 - Product Improvements
V10 - Other System Reliance
V11 - Storage
V12 - Performance Incentives

Since factor analysis is basically a technique for analyzing the interrelationships among the various initial variables, the starting point is the matrix of intercorrelations among these variables. The matrix of correlations indicates the correlations of each variable with every other variable. This is the basic data used in factor analysis and for this research; it is presented in Table II.

This matrix presents the correlation coefficients between each variable; however, since these relationships are difficult to interpret and only indicates the relationships between the variables, the method of principal factoring without iteration and varimax rotation, described in Chapter III, Methodology, is used to identify the underlying factors.

Table III

Rotated Matrix

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|-----------------------|----------|----------|----------|----------|
| Length | .351 | .762* | .124 | .184 |
| Launch Prediction | .619* | .657* | .277 | .004 |
| Launch Delays | .808* | .067 | -.188 | -.089 |
| Complexity | -.355 | .427* | -.382 | .301 |
| Reliability | .634* | .040 | -.106 | .569* |
| Maintainability | .099 | .232 | .310 | .890* |
| Concurrency | -.185 | .760* | -.168 | .018 |
| Design Changes | .412* | .721* | -.113 | .223 |
| Product Improvements | .093 | -.021 | .927* | .305 |
| Other System Reliance | .828* | .101 | .059 | .262 |
| Storage | .099 | .314 | -.891* | -.085 |
| Performance Inc. | -.235 | .437* | .719* | -.132 |

* - indicates significant factor loading

The varimax rotated factor matrix is presented in Table III. This matrix provides factor loadings that allow the underlying

factors to be identified. In order to determine the variables contributing to each of the factors, a factor loading of .40 or higher was used to determine significant loadings.

From this information, the original twelve variables have been reduced to four underlying factors. The next step was to interpret and label these factors and then determine if a significant difference exists between them.

Five of the original variables were significantly loaded on factor 1. These original variables are all related to the program uncertainties: the inability to predict launch dates, launch delays, reliability constraints, design changes, and other system reliance; therefore factor 1 was labeled the uncertainty factor. Six of the original variables were significantly loaded on factor 2, labeled the schedule factor. These variables were all schedule drivers: the length of system build, launch prediction, complexity, concurrency, design changes, and performance incentives. Factor 3, labeled performance factor, is significantly loaded with three variables: product improvements, storage, and performance incentives. In this case, storage is highly negative in its relationship with the factor; however, in space systems, as discussed earlier, improvements are made "up to the last minute" to improve performance. The fourth factor was labeled the logistical factor since it was significantly loaded with the two original variables, reliability and maintainability.

Although these four new factors account for approximately 80 percent of the variance, any significant differences between these factors need to be identified. As previously discussed, a

t-test was conducted with a significance level set at .05. With the sample size of 19 cases, a t value larger than 2.101, regardless of sign, to be significantly different. The results of this test are presented in Table IV. The only factor that was significantly different was the performance factor, Factor 3. It was significantly different from Factors 1 and 2, the uncertainty and schedule factors.

Table IV
t Values Between Factors

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|-------------|----------|----------|----------|----------|
| Uncertainty | N/A | | | |
| Schedule | -.717 | N/A | | |
| Performance | -3.017* | -2.323* | N/A | |
| Logistic | -.489 | -.353 | .022 | N/A |

* - represents a significant difference

Although a significant difference was found between the performance factor and the uncertainty and schedule factors, it should be noted that the sample size used here was only nineteen. This would require a large difference in means to become significantly different, especially at the .05 level. As further research is conducted, significant differences may be found between the other factors. This limitation also provides this research with greater confidence that the significant differences that were found represent legitimate differences.

Qualitative vs Factor Analysis Results

When comparing the factor analysis groupings with the rankings provided by the qualitative analysis, the significant factor loadings for each underlying factor tend to group together with only two exceptions. Factor 2 is significantly loaded with six of the variables; however, the performance incentive variable does not group together in the qualitative ranking. The other exception, factor 4, is significantly loaded with only two of the original variables, reliability and maintainability, which are almost at opposite extremes in this ranking. Possible reasons for this were presented under each of the variable discussions provided earlier.

V. Conclusions and Recommendations

This chapter presents the conclusions drawn from the analysis presented in Chapter IV, Discussion and Findings. In addition, this chapter will present ideas to improve the space related program acquisition process and ideas for further research.

Conclusions

This research identified twelve operational variables that previous research used to describe the problems encountered in space related program weapon system acquisition. These twelve variables were reduced to four underlying factors. Factor analysis was used to accomplish this reduction in factors.

From the twelve original variables, four underlying factors were identified and accounted for 78.3 percent of the variance. The four factors are labeled here as: factor 1, program uncertainties; factor 2, schedule drivers; factor 3, performance drivers; and factor 4, logistical drivers. These factors, when related to the conventional acquisition procedures, are hypothesized as adversely affecting the performance of program managers of space weapon systems. This was a result of the full funding policy and the time availability for new obligations on procurement appropriations.

This research has concluded that these four factors are the limiting factors in space weapon system acquisition. However, the personal interviews conducted allowed for additional conclusions to be drawn. Program managers have learned to

operate within these constraints. They accept, even if they feel it is inappropriate, the full funding policy. These program managers believe that the full funding policy intentions of identifying the total weapon system cost are valid, but also believe that this causes other problems. For example, although a program office obligates funds to the contract price, the actual expenditures will not occur for years to come. With Congress looking at current expenditure rates for future appropriations, the Department of Defense stands to receive less funding than necessary to procure the system. Program managers believe that a change in the full funding policy is necessary to eliminate this problem; however, since a change is not in sight, this research looked more closely at the other factors that limit space related program managers.

When discussing the problem of a three year time availability of the currently used missile procurement appropriation, program managers stated that there were inconsistencies in maintaining the full funding policy after the third year. If the funds existed within the expired or lapsed accounts, approval was given for valid requests. However, if the funds did not exist within these accounts, higher headquarters directed the use of current funds already available in the program office. This would be accomplished by somehow justifying this change as an out-of-scope change to the contract, thus requiring current year funds. In the specific area of storage, if any was anticipated, it would be put into the contract and funds would not be required. If storage was not put into the

original contract, it would be considered an out-of-scope change and current year funds would again be used.

Funding of performance incentives was never really a problem for a three year constraint on new obligations. This is true because any known change, most commonly done for performance incentives, to the contract beyond the three year constraint can be committed as a contingent liability. This effectively reserves the funding required for any known changes and it cannot be withdrawn from the program office. Program managers have further helped eliminate the problem of reserved funds resulting from the full funding policy requirement. Performance incentives were once written strictly as positive incentives. In this case, funds provided for incentives could not be used for anything else. To help alleviate this problem, program managers are currently negotiating contracts with only negative incentives. This requires no funding commitment from the government.

In answering the research questions, twelve operational variables were used to indentify four underlying factors that are affecting the ability of program managers to effectively manage. In order of importance, they are: program uncertainties, schedule drivers, performance drivers, and logistical drivers. Not all of these factors are unique to space systems; however, the most important factor, program uncertainties, is especially important in space systems. This research cannot fully answer the research hypothesis that space weapon system procurement is not different than the procurement of non-space weapon systems

since the scope of this research did not include comparing these factors to other programs outside of space related programs.

Recommendations for Improvement

In the interview process, program managers were given the opportunity to recommend improvements to the acquisition process for space related program acquisitions. Four of the subjects believed that incremental funding is still the best approach to help eliminate the problems discussed. Only six responded that the length of obligational availability should be extended beyond three years. Almost half (nine) of the subjects stated that no change was necessary in the initial obligational availability of procurement funds. The reasons stated were: the drivers that truly would constrain the program managers can be dealt with in contingent liabilities; although a system may not be near completion, the program manager has very little risk in this area by the end of the third year; and the use of the appropriate contract type, usually fixed price.

In the production phase of many systems, the contract is a fixed price contract. For this contract type, the government obligates the funds necessary for completion of the system (the contract price) and lets the contractor bear the risk of a contract price overrun. No further fund obligations are necessary unless a contract change is made. Any changes to a fixed price contract is considered out-of-scope and current funds are required.

Recommendations for Further Research

The program managers that were interviewed had experiences in a wide variety of positions in space and non-space weapon systems. Although the factors limiting program managers of space related weapon systems were identified here, one logical follow-on research would be to use these factors to examine and compare space and non-space weapon system procurement.

In the studies included in the literature review, the recommendation was made to develop a new space appropriation and to have it incrementally funded. The items to be included in this appropriation were well defined; however, the actual process and the identification of any secondary problems were not identified. This would be a second future research topic.

Appendix A. Interview Questions

General Information:

What is your experience level as a program manager?

What is your experience level in space related systems?

What is your current job title?

Length:

How long does it take to build your system?

Inability to predict launch date:

When budgeting for your system, how well of an idea do you have for an expected launch date?

- within 1 month
- within 3 months
- within 6 months
- within 1 year

Launch Delays:

How many times do you have a launch delay for each unit?

- How long is the average delay?
- Are these directed delays?
- Was it a government delay?
- Was it a contractor delay?
- Are you in a high priority program?
 - PMD priority
 - Classified
- Are you a launch-on-demand program?

Complexity:

What percentage of your system uses off-the-shelf items?

- versus state-of-the-art?
- Are you required to do so?

Reliability:

How do you measure system reliability?

With the high complexity of space systems, what level of reliability do you try to achieve?

- What level of reliability are you required to have?
- Has the Space Shuttle affected your reliability requirements?

Maintainability:

How do you measure system maintainability?

What level of maintainability do you try to achieve?

- What level of maintainability are you required to have?
- Has the Space Shuttle affected your maintainability requirements?

Concurrency:

Did you manage under concurrency?

- What kind of problems did this cause, if any?
 - more design changes?

Design changes:

How many design changes per unit have you had since entering the production phase?

- Did these changes occur after fund expiration?
 - approximately how many?
- Were these within your control?
- Contractor, SPO, or PMD directed (% for each)?
- Did user need?
- Did concurrency cause?
- Did R&D satellite demand need for change?

Product improvements:

How were these improvements incorporated into the system?

- in new buys (pre-planned)?
- incorporate on floor?

Other system reliance:

How reliant on other systems is your program?

- Need for launch vehicle
- Need for advance space systems developed elsewhere
- Need for GFP (black boxes)

Storage:

How do you plan/budget for storage requirements?

Performance incentives:

What type of performance incentives do you plan/budget for?

- Are they due after initial fund obligational availability?

Other:

Does a three year obligational period for the procurement appropriation constrain you in any other way not previously discussed? How?

Working alternatives:

What alternatives do you currently use to avoid the fund obligational time period constraint?

- Do you compromise other factors?

How effective are these alternatives?

- How many days does it take?
- What resources are tied up in order to do this?
- Would changing the obligational time availability period substantially change the need for these alternatives?

Improvements:

How would changing the initial obligational availability time period improve your effectiveness in managing your program?

- Change to 4 years?
- Change to 5 years?
- Change to more than 5 years?

Overall rating:

- 1 - biggest problem
- 2 - second biggest problem

- _____ Length
- _____ Inability to predict launch date
- _____ Launch delays
- _____ Complexity
- _____ Reliability
- _____ Maintainability
- _____ Concurrency
- _____ Design changes
- _____ Product improvements
- _____ Other system reliance
- _____ Storage
- _____ Performance incentives
- _____ Other (please be specific)
- _____ Other (please be specific)
- _____ Other (please be specific)

Individual Factors:

Considering the three year procurement appropriation limitations, how does this factor rate in limiting your ability to effectively manage your program for cost, schedule, performance, or logistic requirements?

- 1 - Extremely Important
- 2 - Very Important
- 3 - Important
- 4 - Neutral
- 5 - Unimportant
- 6 - Very Unimportant
- 7 - Extremely Unimportant

Overall Rating:

Again, considering the three year procurement appropriation limitations, prioritize each factor by how it limits your ability to effectively manage your program for cost, schedule, performance, or logistic requirements.

Appendix B. Statistical Program for Factor Analysis

```
RUN NAME      THESIS STATS
PRINT BACK    CONTROL
VARIABLE LIST  V1 TO V12
INPUT MEDIUM  CARD
INPUT FORMAT   FIXED(12F1)
N OF CASES     19
VAR LABELS     V1,LENGTH/V2,LCHPRE/V3,LCHDEL/V4,COMPLEX/
                V5,RELIA/V6,MAINTAIN/V7,CONCUR/V8,DSGNCHG/
                V9,PRODIMP/V10,OTHREL/V11,STORAGE/V12,PERFINC/
FACTOR         VARIABLES = V1 TO V12/
                TYPE = PA1/
                ROTATE = VARIMAX/

READ INPUT DATA
333224333333
233324233333
333324333333
233234233333
333234233333
333234333333
333234333333
344233333334
233224233333
233324333334
221224333234
223323332252
223334323333
335334333333
112213213123
332324333133
332324333234
332324333234
333324333333
END INPUT DATA
FINISH
```

Principal Component Matrix

| Factor | Eigenvalue | Pct of Var | Cum Pct |
|--------|------------|------------|---------|
| 1 | 3.82888 | 31.9 | 31.9 |
| 2 | 2.66335 | 22.2 | 54.1 |
| 3 | 1.86565 | 15.5 | 69.6 |
| 4 | 1.03381 | 8.6 | 78.3 |
| 5 | .90535 | 7.5 | 85.8 |
| 6 | .70020 | 5.8 | 91.6 |
| 7 | .52507 | 4.4 | 96.0 |
| 8 | .28069 | 2.3 | 98.4 |
| 9 | .11077 | 0.9 | 99.3 |
| 10 | .06256 | 0.5 | 99.8 |
| 11 | .01832 | 0.2 | 100.0 |
| 12 | .00535 | 0.0 | 100.0 |

Orthogonal Matrix

Communality

| | |
|------------------------------|------|
| V1 - Length | .754 |
| V2 - Launch Prediction | .892 |
| V3 - Launch Delays | .700 |
| V4 - Complexity | .545 |
| V5 - Reliability | .738 |
| V6 - Maintainability | .951 |
| V7 - Concurrency | .641 |
| V8 - Design Changes | .752 |
| V9 - Product Improvements | .961 |
| V10 - Other System Reliance | .768 |
| V11 - Storage | .910 |
| V12 - Performance Incentives | .781 |

Appendix C: Glossary of Variables and Key Terms

Variables

Complexity: the type and level of personnel skills required and the tools, equipment, and facilities required in determining the levels of maintenance and modification.

Concurrency: the simultaneous addressing of the problems of training for, logistically supporting, and eventually operationally employing a system by the coordinated effort of assigned personnel throughout the definition and the acquisition phases of the system program. This is most often done during the full scale development and production phases.

Design Changes: any change in design, plan, or drawing that affects the configuration and/or mechanics of a part, assembly, component, or end item.

Inability to Predict Launch Date: the probability that the launch date set in the original schedule will change.

Launch Delays: the number and length of launch delays per unit.

Length: the total system build time from contract award to delivery. This does not include any advance buy time.

Maintainability: a characteristic of design and installation expressed as the probability that an item will be restored to a specified condition within a given period of time when maintenance is performed using prescribed procedures and resources.

Other System Reliance: the type and percentage of reliance on

other system programs that is required by a specific system to meet mission requirements.

Performance Incentives: a method used to motivate the contractor in calculable monetary terms to turn out a product that meets significantly advanced performance goals.

Product Improvements: the method of incorporating product improvements, either immediately on the production line or in a pre-planned product improvement program.

Reliability: the probability that the material/system will perform its intended function for a specified period of time under stated conditions.

Storage: the keeping or placing of property in a warehouse, shed, open area, or other designated facility.

Key Terms

Acquisition: the process of planning, designing, producing, and distributing a weapon system. This includes the conceptual, validation, full scale development, production, and deployment/operational phases of the weapon system.

Advance Buy (Long Lead Procurement): procurement to provide for components that require a longer lead time than the system of which they are a part.

Appropriations: an authorization by an Act of Congress to incur obligations for specified purposes and to make disbursements out of the Treasury.

Authorizations: an Act of Congress that sets upper limits of funding for specified purposes.

Communality: the proportion of the total variation in each variable explained by all the factors used. It is the squared multiple correlation between the variable and the factors.

Contingent Liability: funds set aside to provide for unforeseen expenditures or for anticipated expenditures of an uncertain amount.

Contract Option: a unilateral right by which, for a specified time, the Government may elect to purchase additional supplies or services.

Eigenvalues: each component's total variance accounted for by the factor.

Expired Appropriation: an account that is no longer available for obligation but is still available for disbursement to liquidate existing obligations.

Full Funding: the policy of funding the total cost of an end item of material to be procured at the time it is authorized to be initiated.

Incremental Funding: the citation of funds on a contract in an amount necessary to continue the effort for one fiscal year.

Lapsed Funds: funds in an account that is no longer available for payment of obligations. The unliquidated obligations are transferred to the successor "M" account. This closing normally will be accomplished two years after the appropriation has expired.

Negative Incentives: a type of performance incentive that requires no additional funding by the government. If the

system does not meet the contract provisions, the contract provides a monetary payment to the government.

Obligation: a legal requirement for disbursement of funds based on orders placed, contracts awarded, services received or other contractual documents.

Operational Indices: the variables used to indicate the presence of one or more underlying factors when conducting factor analysis.

Orthogonal Rotation: a method used in factor analysis to identify independent factors.

Out-of-Scope: a change to the system that was not in the original contract. This usually requires additional funding that must come from current appropriations.

Positive Incentives: a type of performance incentive that the government would require additional funds to pay the contractor after the system had met contract provisions.

Principal Components: in factor analysis, a variable that can be decomposed into n components and predicted exactly from these components.

Procurement: the process of obtaining personnel, services, supplies, or equipment.

Reprogramming: an adjustment to a previously established program in order to meet the required mission outlined by higher headquarters in current and/or prior years.

Work Arounds: a secondary method of making the system or process capable of working.

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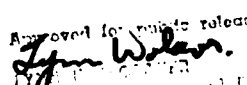
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The full funding policy and the three year obligation availability of procurement funds were identified as the major constraints limiting program managers of space weapon systems in their acquisition activities. In order to evaluate the effect of these constraints on space weapon system acquisitions, twelve variables, identified through the literature review, were used to gain an understanding of the problem. Program managers believed that these variables created problems that could only be solved by changing the acquisition process.

Personal interviews were conducted and the importance of each variable in affecting the program manager's efficiency was identified. Two data analysis techniques were used: qualitative and factor analysis. Factor analysis was conducted using the rating of importance for each variable and this lead to four underlying factors. The factor identified as limiting program managers the most was labeled program uncertainties.

From the program manager's viewpoint, the study resulted in a finding that, although one constraint (three year obligational availability of procurement funds) was not optimal, it was acceptable. Program managers of space weapon systems have demonstrated this by adapting their methods to operate within this time limit. The full funding policy constraint, however, continues to be a problem, and should be reviewed.

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